Development Cost Cause-and-Effect Diagramming, Pareto Analysis, and Future Methodologies

presented to
33rd DODCAS

Gerry Belcher, LMI
John Geisen, OSD(PA&E)

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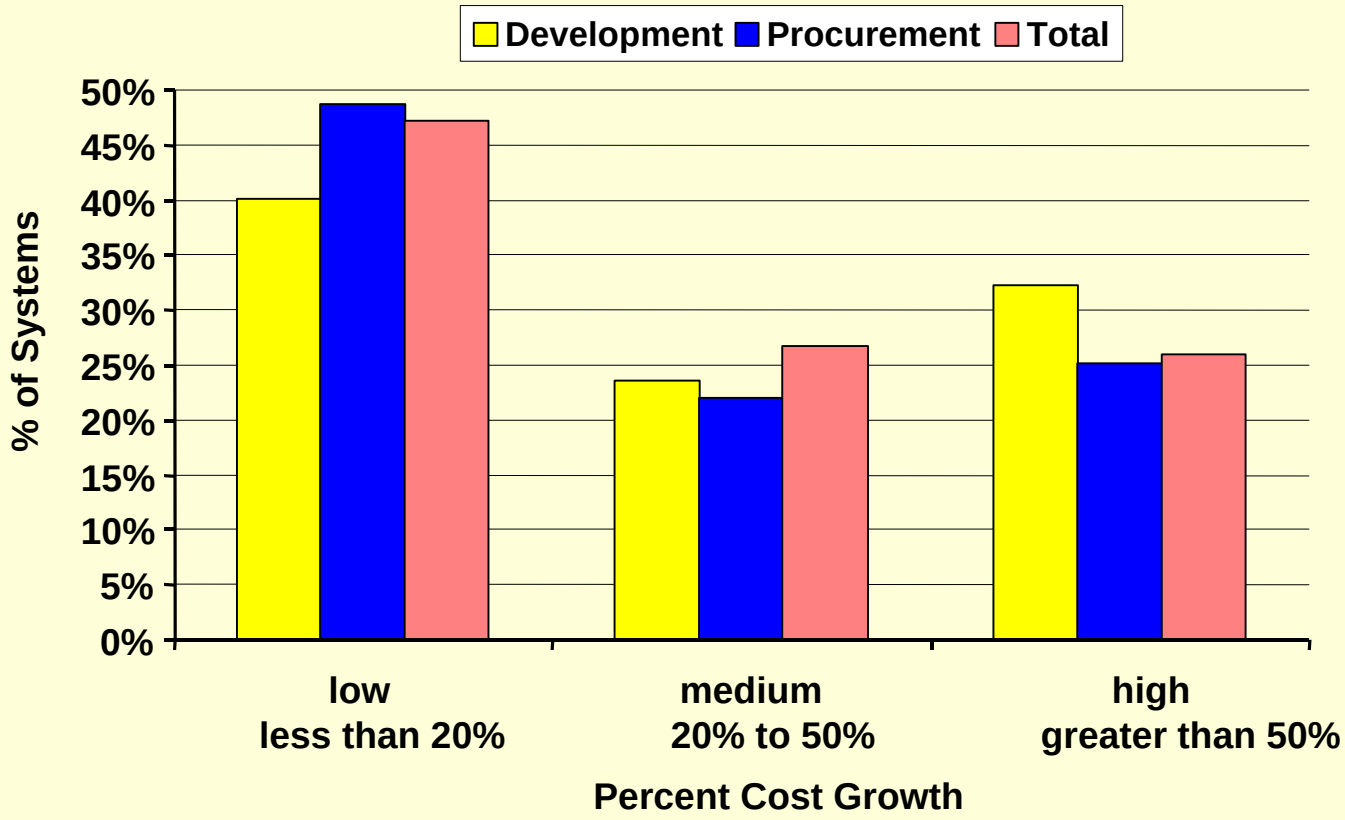
Programs Experiencing Cost Growth



SOURCE: OSD CAIG

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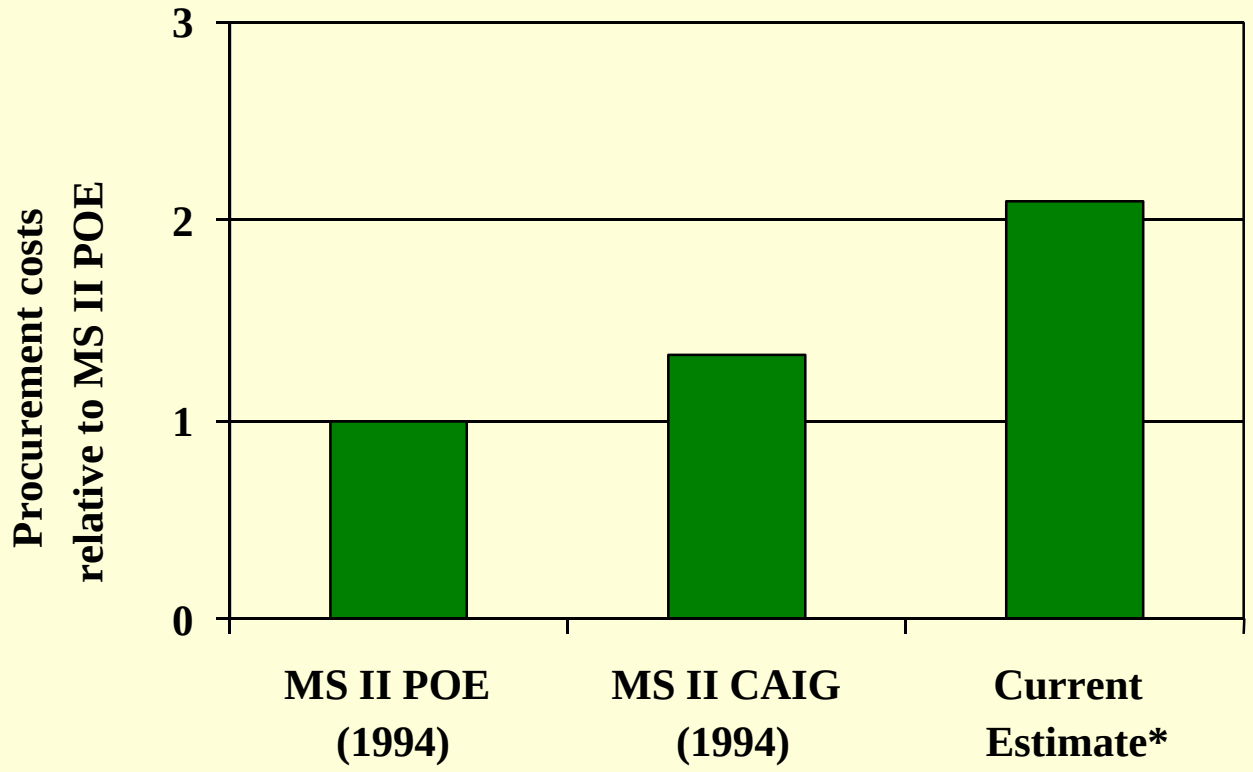
Patriot PAC-3 Cost Estimates

(Cost of procuring 1200 missiles)



*As of Oct 98

Background

- Times have changed...so have development activities
- Research indicates that legacy estimation methods have not kept pace
- CAIG wants to:
  - Understand current development processes
  - Identify cost drivers and relationships
  - Develop improved estimation methods

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Background

Research to date (*on defense electronics*), found:

Development cost estimates were wrong, in part, because they--
- were based on overly optimistic, success-oriented schedules
- were based on perfect matches of people with work
- did not allow for adjustments to technology trends
- did not allow for adjustments with program changes

and...

Development drivers for these products were determined to be--
- complexity of software
- complexity of hardware integration
- the number and variety of interfaces required
- the developing firm's experience and sophistication

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The Issue

What causes development cost?

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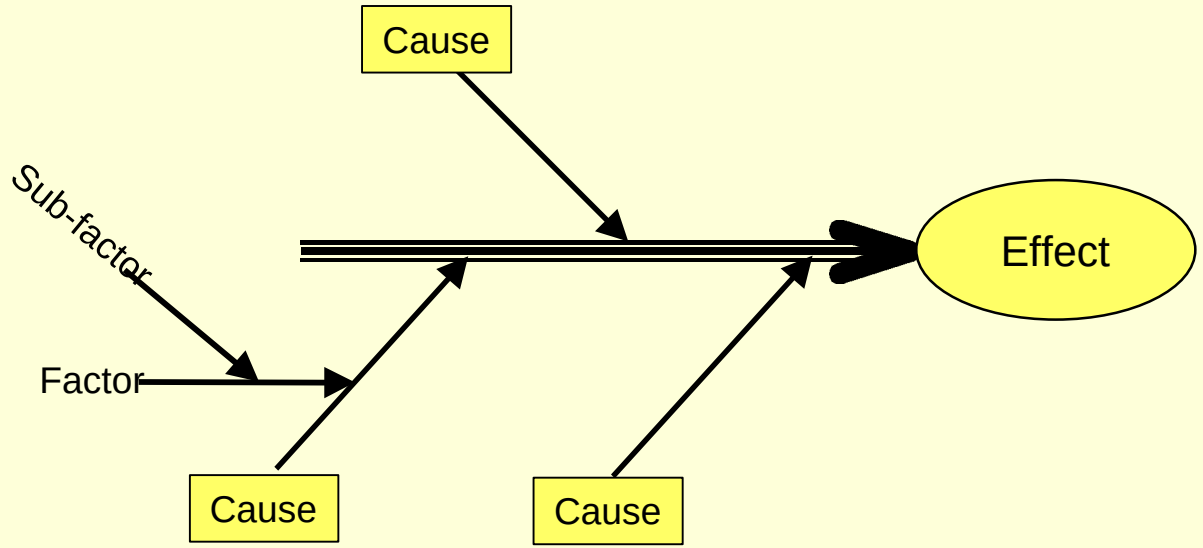
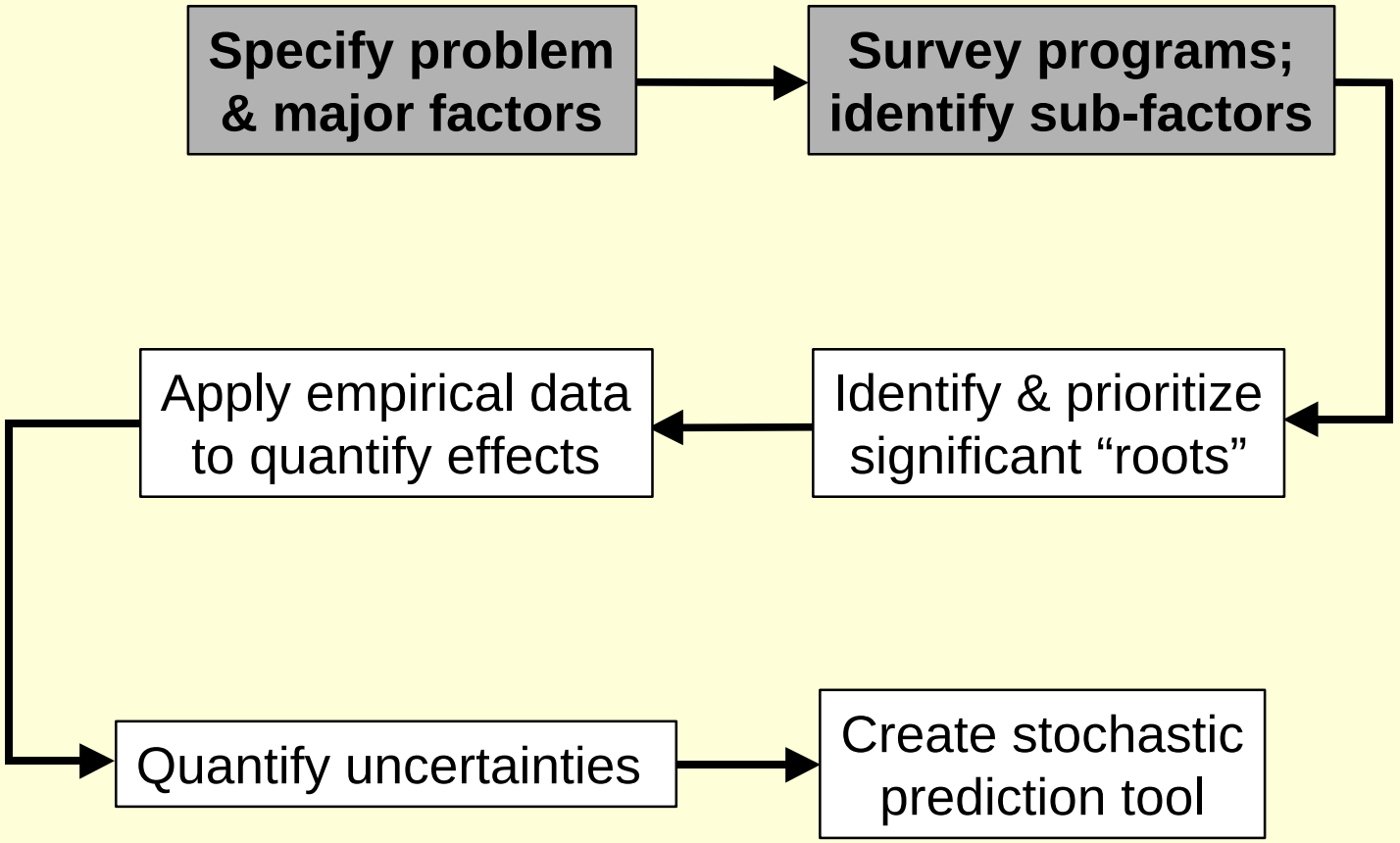
Cause-and-Effect Diagrams

- Structured approach to finding “root” causes
- Reveals *relationships* between causes and effects
- Facilitates data collection



Approach



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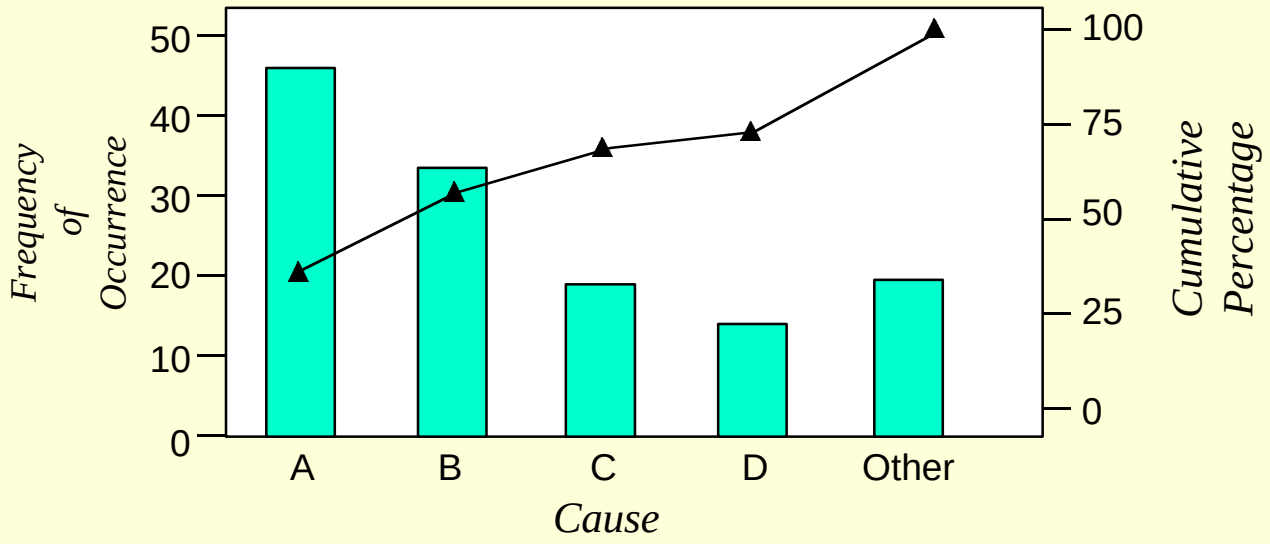
Pareto Analysis

"20% of the problems have 80% of the impact"

- Facilitates identification of the "vital few" factors
- Facilitates corrective action decisions



Where to Start

What are the major factors of development cost?

- Schedule?
  - Scope?
    - Personnel utilization?
      - Technical/physical characteristics?
        - External (political) influences?

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The Concept

Development Cost = Scope x Productivity x Economic Factors

where,

Development Cost ≡ $

Scope ≡ work

Productivity ≡ hours/work

Economic Factors ≡ $/hours

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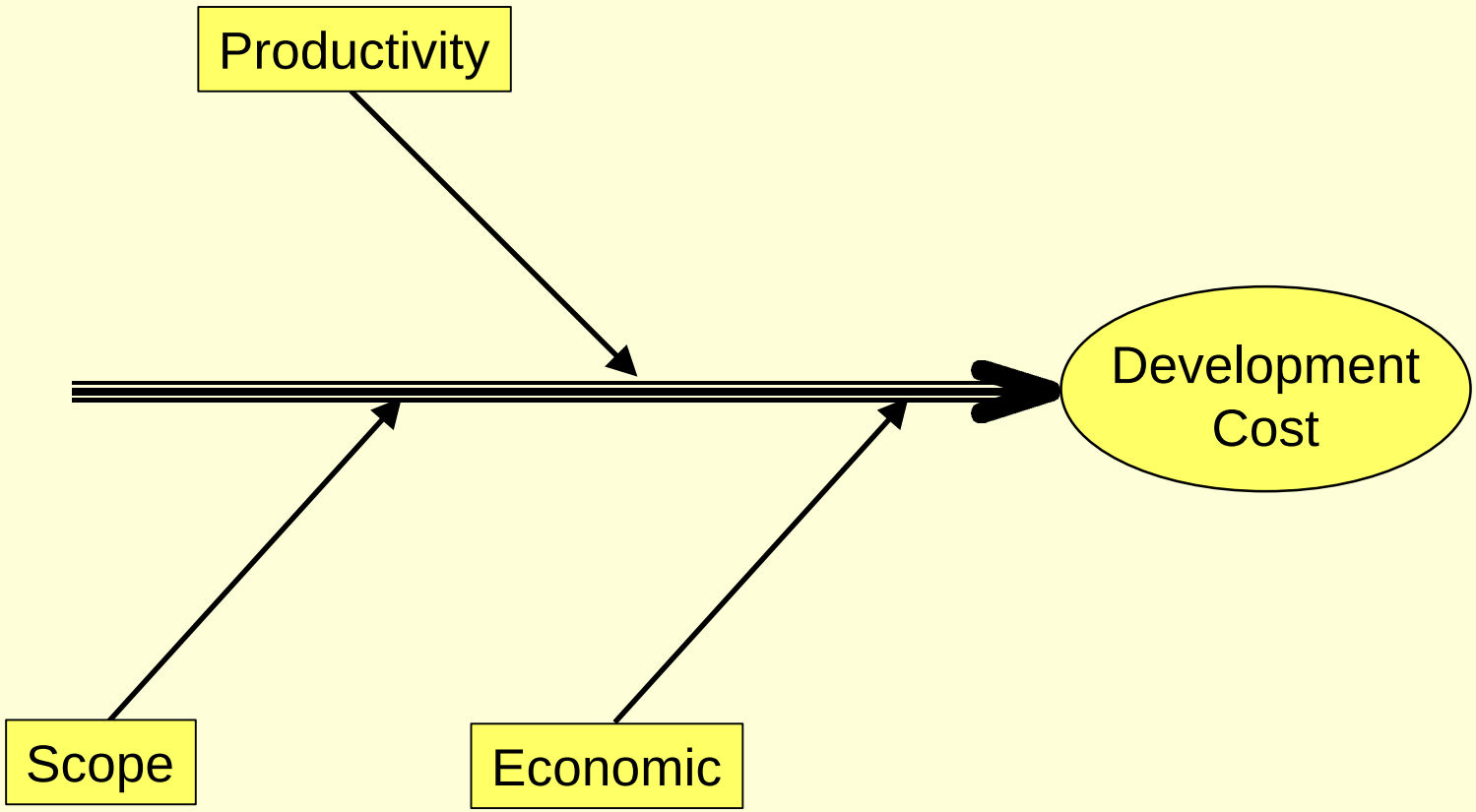
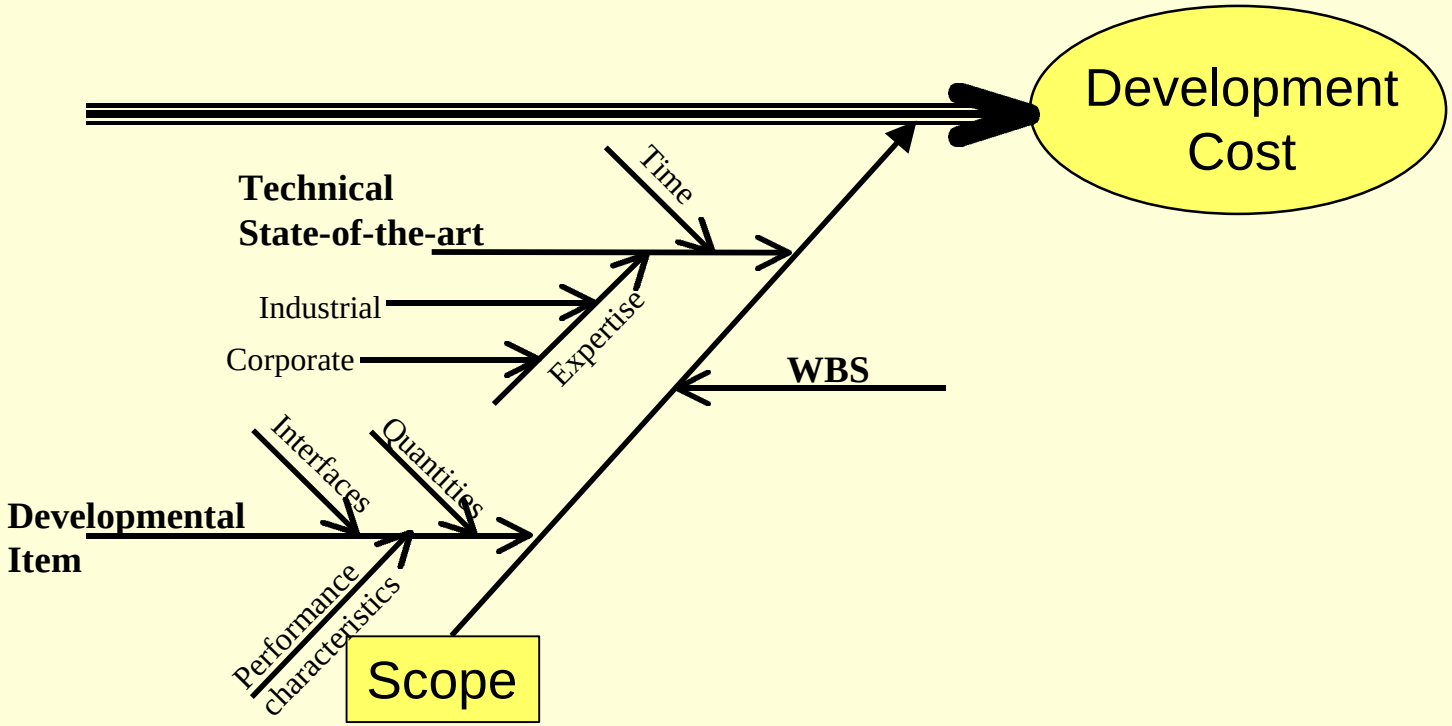
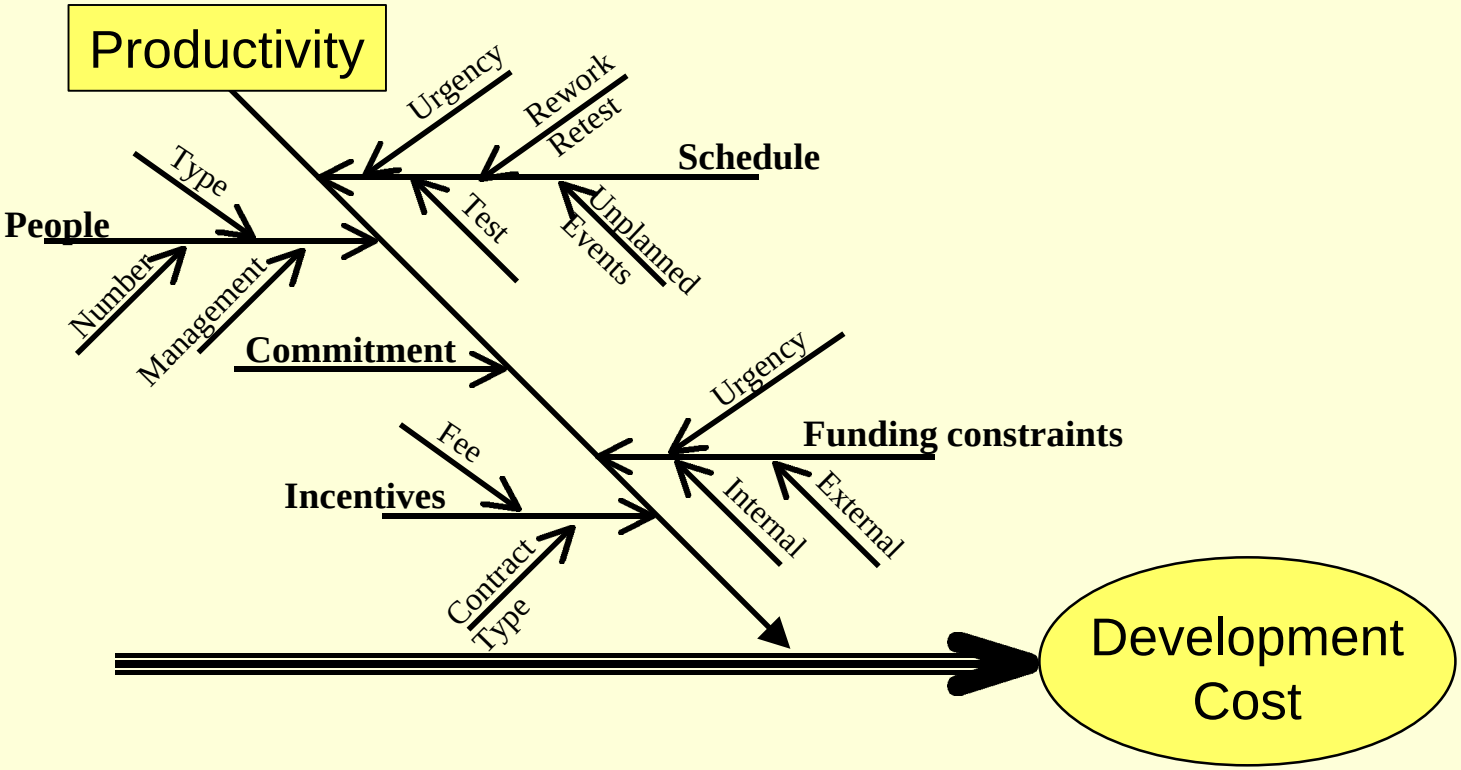
The Basic Model



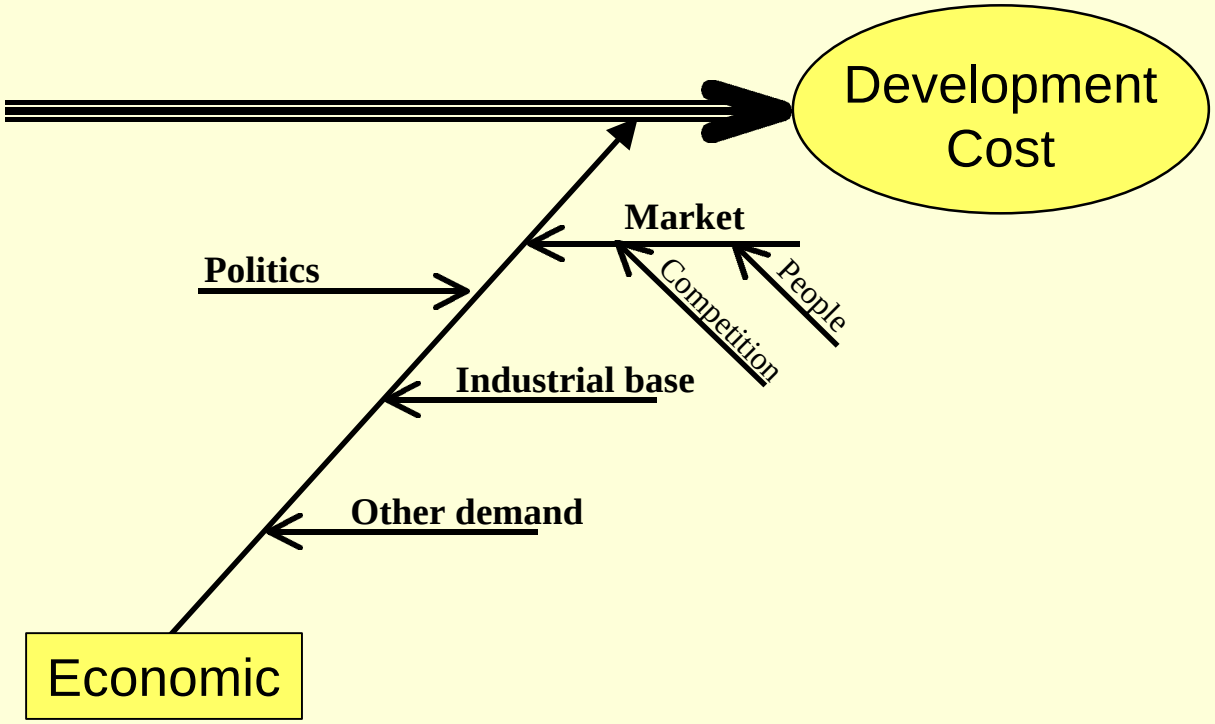
Scope of the Project



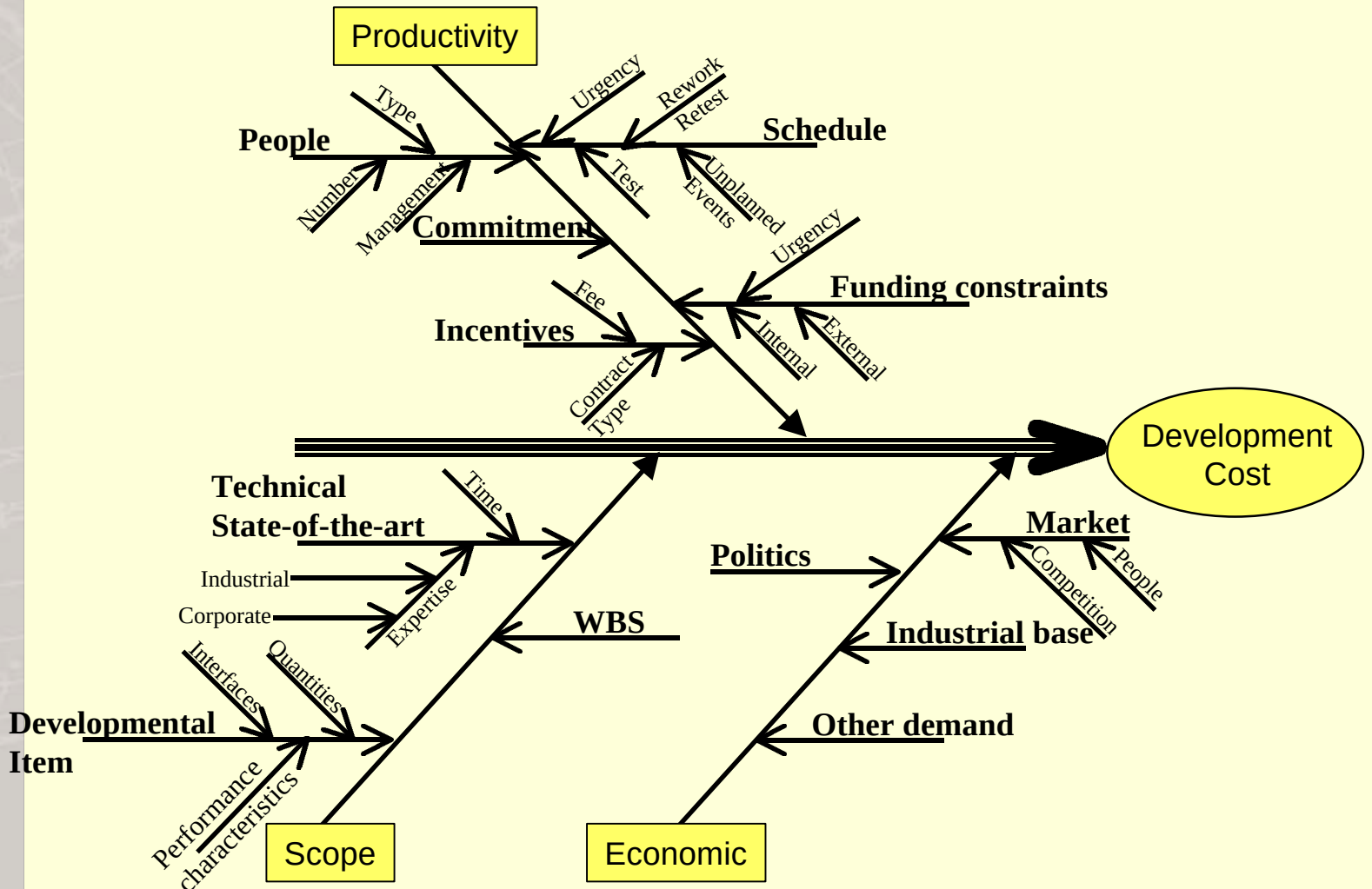
Project Productivity



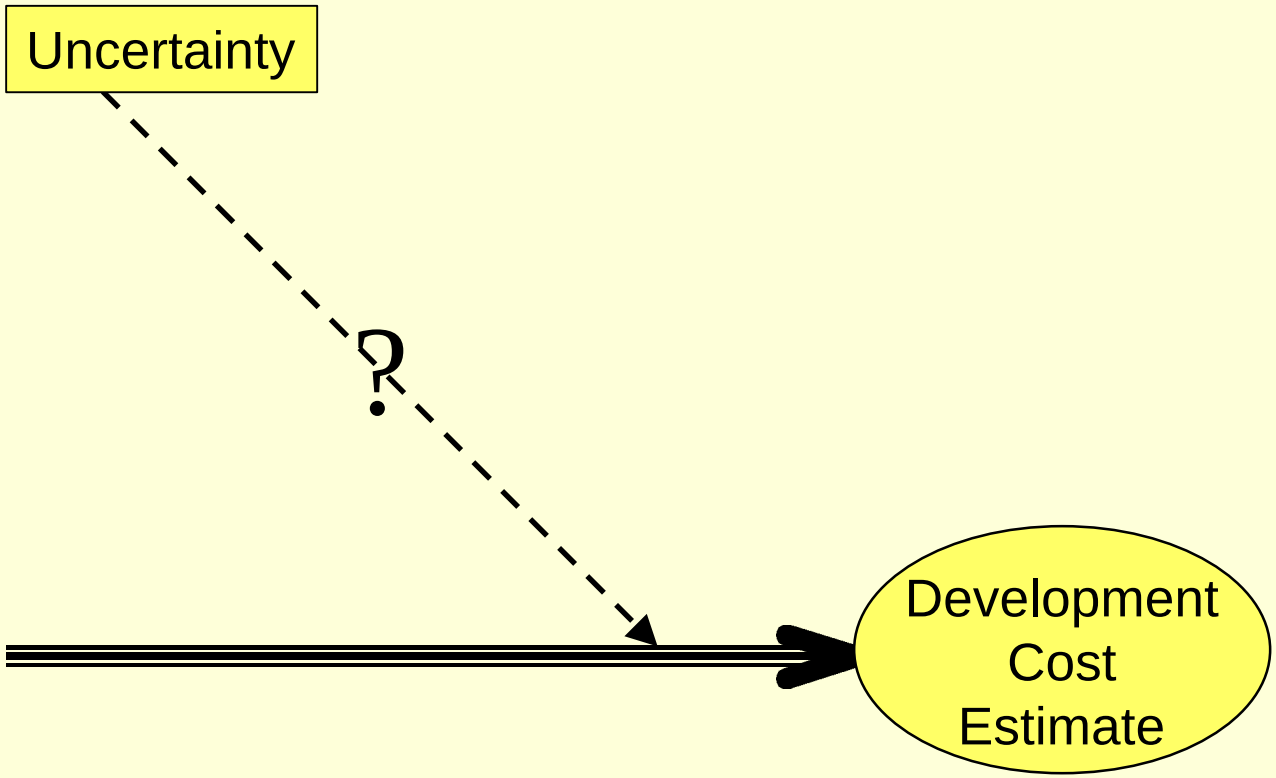
Economic Factors



Full-up Model



Applying Uncertainty



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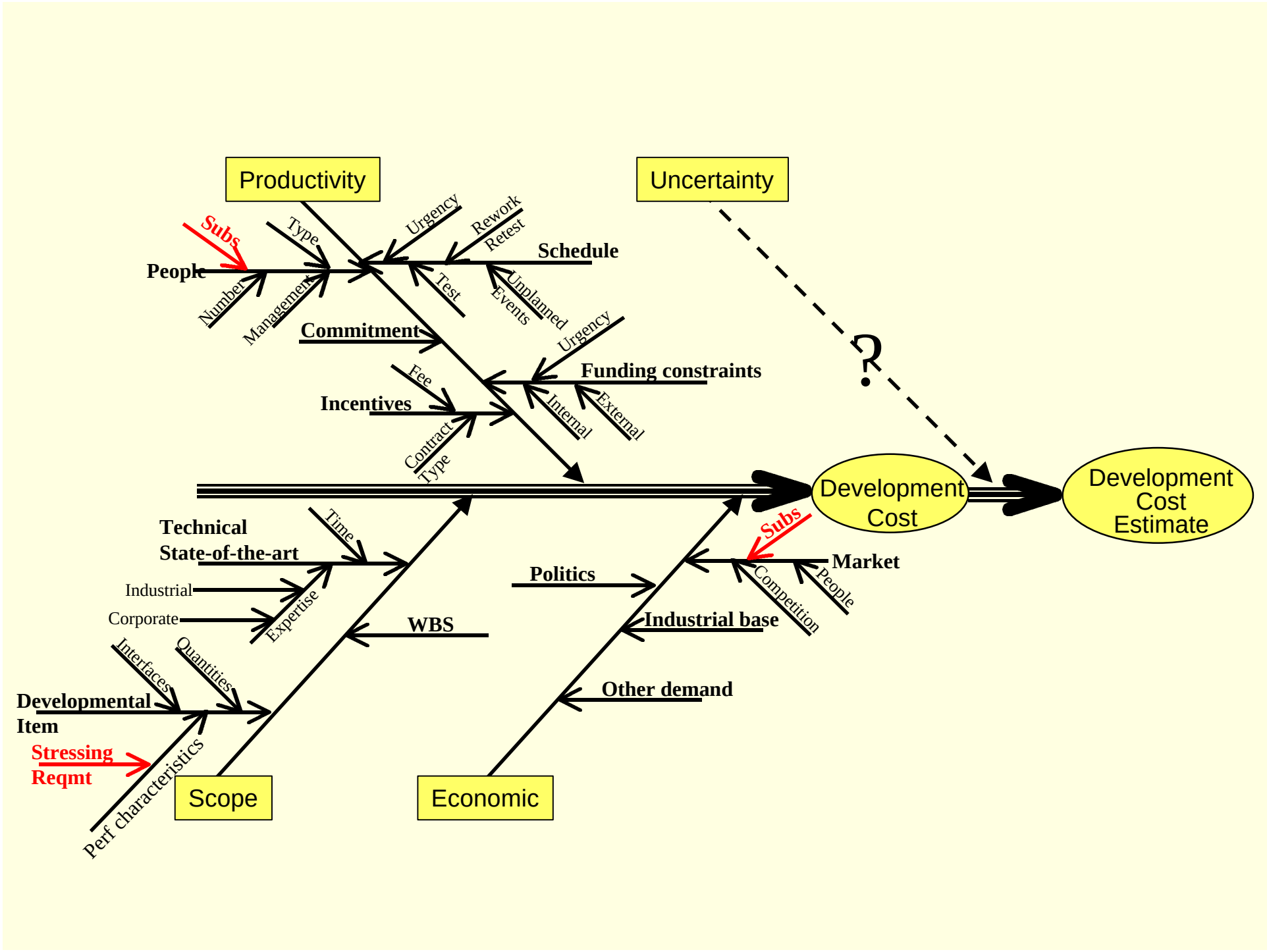
Productivity
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WBS
Industrial base
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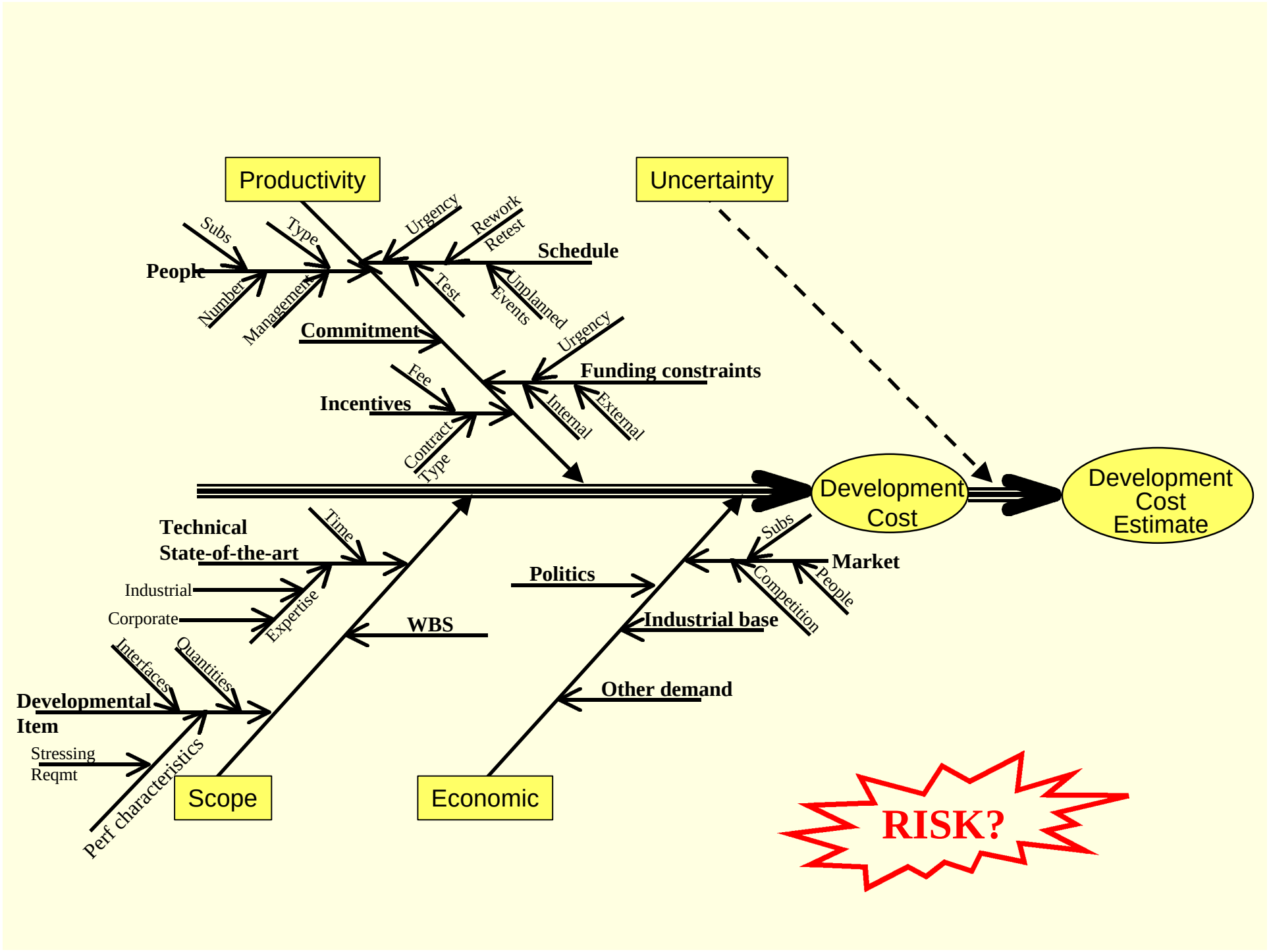
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RISK?

Observations

- Basic model is adequate representation of development cost's major factors
- A stressing requirement may be viewed as a "root" of development cost (i.e., hit-to-kill)
- Subcontractors' contributions to cost must be evaluated explicitly
- Developers and estimators need ***detailed*** understanding of requirements
- Integration and test activities and resources are routinely underestimated

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Summary

- Basic approach shows promise:
  - Determine causes, find roots/relationships
  - Validate with empirical data
  - Apply uncertainty to build estimator
- C-E diagrams
  - organizes analysis to get at root causes
  - shows relationships between factors
  - facilitates data collection
- Pareto analysis
  - separates “vital few” from “trivial many”
  - facilitates decision-making
- Cost model must deal with the concept of risk

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So, where do we go from here?

It's time to open the aperture.

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Taking a New Approach

- Attributes desired in New Approach
  - Time - integral to each WBS
  - Realistically capture dependencies within the program
  - Provide means to evaluate schedule & cost risk
  - Flexible enough to be modified as changes occur over time
  - Results should be intuitive

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Taking a New Approach (Cont)

- Goal of New Model
  - More precise, accurate and flexible modeling tool
- What do we do first
  - Try the approach on a sample problem to:
    - » evaluate its potential,
    - » determine additional data needs,
    - » determine practical use

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Proposed Model

- Program Execution Model:
  - Built as a Discrete Event Simulation
  - Work Packages (Nodes) - Sequentially pass through the Packages Based on Precedence
  - Completion of Each Package is Dependent Upon a Bivariate Distribution of Effort & Time
  - Constrained by Funding

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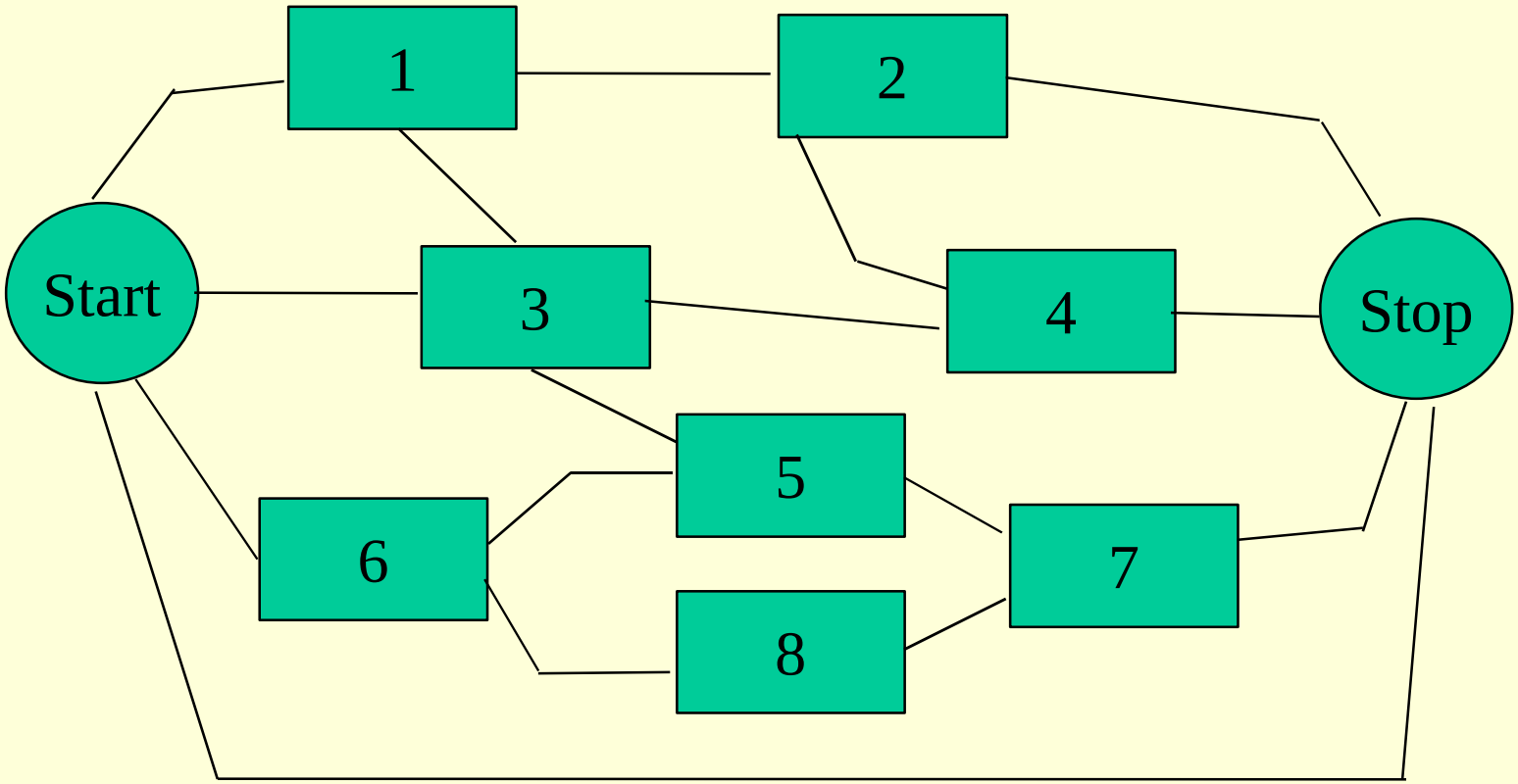
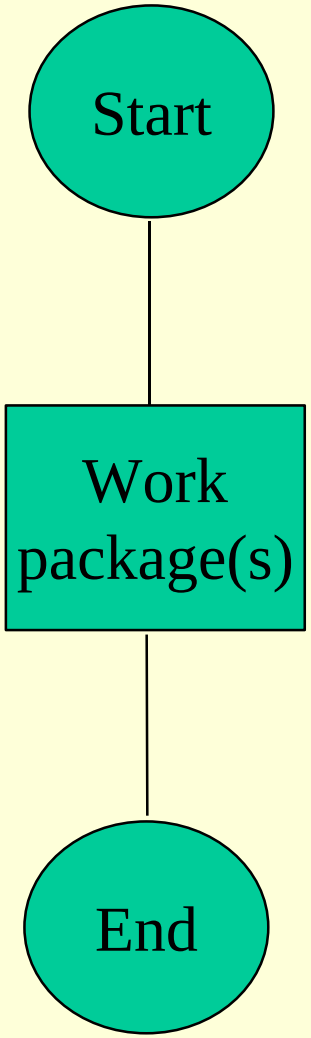
Proposed Model (Cont)

Generalized Precedence Diagram



Proposed Model (Cont)



Each Arc Represents a Bivariate Distribution of Effort & Time

Completion of the Work Package is Dependent Upon the Effort & Time

Output - Distribution of Program Cost & Distribution of Program Schedule

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Future Work

- Build the Model
  - Commercial Simulation Package vs Home-made Program
- Data
  - Determine what is needed.
  - How will it be collected?
    - » Redesign Current CCDRs?

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